Journal of Applied Agricultural Science and Technology
6(2): 171-179 (2022)
E-ISSN: 2621-2528
ISSN: 2621-4709

THE EFFECT OF TOFU LIQUID WASTE AND ORGANIC MULCH ON THE GROWTH OF COCOA (*Theobroma cacao* L.) NURSERY PLANTS IN A POLYBAG

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Abstract*. This study aims to examine the influence of the concentration level of organic tofu liquid waste and rice straw mulch on the growth of cacao (Theobroma cacao L) seedlings. It was carried out using three variables, namely the concentration of tofu liquid waste and four treatment levels. These include treatments without tofu liquid waste 0 ml/kg/plant (T0), and with 60 ml/kg/plant (T1), 80 ml/kg/plant (T2), and 100 ml/kg/plant (T3), respectively. Furthermore, rice straw organic mulch factor with three levels, namely 15 gr/plant (15 tons/ha) (M1), 20 gr/plant (20 tons/ha) (M2), and 25 gr/plant (25 tons/ha) (M3) was also used. The results indicated that the concentration of liquid organic fertilizer derived from tofu liquid waste significantly affected plant height at the age of 3 months. The tallest plant measured 64.78 cm in height, with 21.33 leaves, stem diameter of 0.72, and leaf area of 17.58 cm^2. Organic rice straw mulch did not have a significant effect on all plant factors. This showed that the application of liquid organic fertilizer tofu waste influences plant height, leaf number, and stem diameter, and there is no effect on the leaf surface, while rice straw mulch did not alter all plant variables.*
Keywords: *cocoa seeds; polybags; rice straw mulch; tofu waste*

1. Introduction

Cocoa (*Theobroma cacao L.*) is among the export commodities with high economic value in Indonesia, which has the potential to earn foreign exchange. It is a source of raw materials for the cosmetic and pharmaceutical industries and also provides a multibillion-dollar chocolate industry containing potential health benefits. This is because of rich polyphenols, as well as flavonoid contents (Wickramasuriya *et al.*, 2018), and has become a source of employment for residents in production centers. Cocoa is Indonesia's third greatest foreign exchange earner after rubber and palm oil, which contributes to regional development and agro-industry. The production is determined by weather conditions, leading to an undetermined change in price. When this happens continuously, the volatility of cocoa prices tends to be high (Widayat *et al.*, 2019). Moreover, there must be a balance against the country's domestic production due to the demand for cocoa beans, which continuously increases as the processing sector develops.

In Indonesia, the total production of cocoa is approximately 27.6%, with a productivity level of 655,515 kg per hectare. Although the government's policy towards its inputs and outputs is effective. This is because of the PCR value of 0.51, indicating that cocoa farming has a competitive advantage, but not a comparative benefit. This makes it necessary to increase productivity, out-put prices, as well as exchange rates, and reduce input (Fahmid *et al.*, 2018).

Received February 5, 2022; Accepted August 15, 2022; Published August 31, 2022
https://doi.org/10.55043/jaast.v6i2.56

One of the strategies to increase national cocoa production is to focus on all elements of cultivation, beginning with the nursery (Feby *et al.*, 2021). This stage plays a critical role in producing high-quality seeds, and the planting medium component is also essential due to its impact on the nursery's success (Famuwagun, 2019). A healthy seedling growth rate during the nursery stage is crucial for cocoa plants' natural growth (Saajah & Maalekuu, 2014). Several efforts have been taken to obtain the desired seeds, including delivering nutrients in the planting environment that match the seedlings' nutritional requirements (Sugito, 2002). It was also discovered that organic matter such as compost tea and chicken manure, can be used as fertilizer since it builds favorable soil aggregate, biology, and chemical composition of the soil (Kasim *et al.*, 2021).

Since fertilization improves nutrient availability in soil, it can be used as a method of increasing cocoa production and plant quality (Kamphuis, 2017). Proper fertilization during the vegetative stage of cocoa plants will improve development and boost the plant's resistance to pests and diseases. One of the fertilizers that are commonly used by farmers is liquid organic fertilizer.

Although tofu liquid waste is an organic fertilizer that can be used on the cocoa plant, it has not been widely employed despite its availability (. It is a byproduct of the washing, soaking, collection, and printing of tofu. According to Asmoro & Susanto (2016), the waste contains 40-60% protein, 35-50% carbohydrate, and 10% fat. A previous study stated that as protein in liquid tofu waste degrades in the soil, it releases nitrogen molecules, which are subsequently absorbed by plant roots. Desiana *et al*. (2013) also discovered that administering the waste at a dose of 80 ml/kg soil influenced plant height, fresh weight, and dry weight.

Apart from fertilization, the good cocoa output can be obtained by establishing favorable soil physical conditions for roots. This can be achieved through soil maintenance with organic mulch. Meanwhile, mulching affects and maintains several physical properties of the soil, including the stability of soil aggregates, density, and inhibits weed growth. It also increases organic matter, protects the surface from water blow energy, and maintains the temperature to encourage nutrient provision by plant roots (Cataldo *et al.*, 2021).

Rice straw is a type of organic mulch that can be used to suppress weed development, maintain soil temperature, and increase the organic matter of the soil (Takakai *et al.*, 2020). Ginting (2019) discovered that applying straw at a rate of approximately 5 tons/ha to sweet potato (*Dioscorea alata L*) can increase the percentage of growth and maintain plant water moisture during growth. This depends on the amount of available water that can be explored by the roots, with mulching treatment. According to Král *et al.*, (2019), straw mulch reduces evaporation and increases humidity, impacting nutrient absorption and metabolism, which leads to higher plant growth. Therefore, this study aims to investigate the effect of organic farming mulch from rice straw and

tofu liquid waste to promote the growth and production of cocoa in nurseries. This experiment is a preliminary study on the value-added of tofu waste and rice straw.

2. Methods

2.1. Media Preparation

The media was prepared before seeding and the soil surface was collected from Farmer land, Eka Suka 11 street, Pangkalan Mansur, Medan Johor regency. The soil surface was hoed and cleaned of roots and weeds, mixed with cow manure in a ratio of 4: 1. Subsequently, the soil mixture was put into polybags weight 5 kg, 13 cm in diameter, and the height of 22 cm.

2.2. Seed Preparation

The seeds used were taken from the center of the fruit (1/3 part of the seed strand), which was physiologically ripe. They were cleaned of pulp using rubbing ash and washed with clean water.

2.3. Seed Germination

The germination tank was filled with 20 cm thick sand, the seeds of uniform size were placed at a spacing of 5 cm x 3 cm, and planted with the radicle eye facing downwards. The seeds were planted in an upright position, where one-third was above the soil surface. Watering was performed two times a day, morning and evening, which was carried out when needed to prevent water intervention.

2.4. Transfer of Sprouts to Polybag

Sprouts were transferred to polybags after 14 days in the nursery or had radicles. The sprouts used were normal, has uniform size, and planting was carried out by manually punching holes in the soil according to the length of the radicle. Sprouts are planted as far as the root neck, and the cotyledons are above the ground.

2.5. Application of Tofu Organic Fertilizer and Rice Straw Organic Mulch

The organic tofu fertilizer was applied by watering the plant's roots with a concentration according to the treatment. The first application was carried out at the age of 1 month and repeated at the same intervals until the seedlings are 3 months old. Furthermore, organic rice straw mulch was administered when the plant was 1 month old by spreading on polybags according to the treatment.

2.6. Variable and Plant Observation

Plant Height (cm)

Plant height was measured at the age of 3 months after planting by measuring from the soil surface to the highest point of growth. The sample plant was given a benchmark as a measurement reference.

Number of Plant Leaves (strands)

The number of leaves that opened completely was counted when the plants were 3 months.

Plant Stem Diameter(mm)

Stem diameter was measured when the plants were 3 months using a *Schlieffen*.

Leaf Area of Plant (cm^2)

The leaf area of sample plants was measured using a roller by measuring the length and width of the fully developed green leaves, while the red ones were not used. The formula stated below was used to calculate the leaf area (Equation 1).

$$Y = p\ x\ l\ x\ 0.56 \quad (1)$$

3. Results and Discussion

3.1. Plant Height

The data for estimating the average height of cocoa plants started from the first to the last measurement, which ranged from 1 to 3 months after planting. From the statistically processed results, the latest data is 3 months after planting. It was discovered that the application of tofu liquid waste significantly influenced the height of 3-month-old cocoa plants, while the organic mulch with 2 treatment elements had no effect.

Table 1. Test Results Average Effect of Liquid Waste Tofu and Rice Straw Organic Mulch on Cocoa Plant Height (Cm) 1 - 3 months old.

Treatment	M1	M2	M3	Average
T0	52.00	52.33	55.33	53.22 a
T1	58.00	59.33	53.67	57.00 b
T2	60.00	60.00	62.00	60.67 b
T3	63.00	65.33	66.00	64.78 c
Average	58.25	59.24	59.25	

Note: T = tofu waste. M = Rice straw mulch. Numbers followed by unequal letters in the same treatment column were significantly different at the 5% level based on Duncan's Distance Test. Those that were not notated showed no significant difference.

Table 1 shows the average test results for tofu waste and organic mulch on plant height 3 months after planting. It was discovered that the liquid tofu waste has a substantial impact on cocoa plant height. The highest plant height was obtained in treatment T3 (100 ml/kg), which was 64.78 cm, followed by treatment T2 (80 ml/kg), T1 (60 ml/kg), and T0 (control) which were 60.67 cm, 57.00 cm, and 53.22 cm, respectively.

Organic rice straw mulch did not influence cocoa plant height, but the highest plants were obtained in the M3 treatment (25 g/plant), which was 59.25 cm, followed by the M2 (15 g/plant) and M1 (15 g/plant), with values of 59.24 cm and 58.25 cm, respectively.

3.1. Number of Leaves (Strands)

The application of tofu liquid waste and organic rice straw mulch significantly influenced the number of leaves of cocoa plants 3 months after planting. However, the interaction of the 2 treatment elements had no significant effect.

Table 2. Test Results Average Effect of Liquid Waste Tofu and Rice Straw Organic Mulch on Number of Leaves (strands) Age 3 months.

Treatment	M1	M2	M3	Average
T0	14.67	16.67	17.67	16.34 a
T1	18.00	18.33	18.67	18.33 b
T2	18.67	19.00	1967	19.11 b
T3	20.33	2100	22.67	21.33 c
Average	17.92 b	18.75 b	19.67 a	

Note: T = tofu waste. M = Rice straw mulch. Numbers followed by unequal letters in the same treatment column were significantly different at the 5% level based on Duncan's Distance Test. Those that were not notated showed no significant difference.

Table 2 summarizes the results of an average test that examine the effect of tofu liquid waste and organic rice straw mulch on the number of leaves aged 3 months. It was discovered that the application of both treatments significantly influenced the number of cocoa leaves. However, the interaction of the 2 treatment components had no significant effect.

The provision of tofu liquid waste gave the highest number of leaves obtained in treatment T3 (100 ml/kg), which was 21.33 strands, followed by T2 (80 ml/kg), T1 (60 ml/kg), and T0 (control), which were 19.11 strands, 18.33 strands, and 16.34 strands, respectively. During the administration of organic mulch with rice straw, the highest number of leaves 19.67 strands was obtained in the M3 treatment (25 g/plant), followed by M2 (20 g/plant), and M1 (15 g/plant), which were 18.75 strands and 17.92 strands, respectively.

3.3. Rod Diameter

The results of the average stem diameter from the age of 1-4 WAP are shown in appendices 13 and 15, while the list of variances is in appendices 14 and 16.

The analysis's findings indicate that the administration of liquid tofu waste has a significant influence. However, the organic rice straw mulch and their interaction did not affect stem diameter 3 months after planting.

Table 3 summarizes the results of an average test on the influence of applying both treatments on stem diameter 3 months after planting. As shown in Table 3, tofu liquid waste has a significant effect on the cacao plant's stem diameter. The diameter was 0.72 mm in treatment T3 (100 ml/kg), followed by 0.70 mm, 0.65 mm, and 0.61 mm in treatment T2 (80 ml/kg), T1 (60 ml/kg), and T0 (control), respectively.

Table 3. Test Results Average Effect of Liquid Waste Tofu and Rice Straw Organic Mulch on Stem Diameter (mm) at 3 months of age

Treatment	M1	M2	M3	Average
T0	0.58	0.61	0.63	0.61 b
T1	0.63	0.64	0.67	0.65 b
T2	0.70	0.70	0.70	0.70 a
T3	071	0.73	0.73	0.72 a
Average	0.66	0.67	0.68	

Note: T = tofu waste. M = Rice straw mulch. Numbers followed by unequal letters in the same treatment column were significantly different at the 5% level based on Duncan's Distance Test. Those that were not notated showed no significant difference.

The application of organic rice straw mulch did not significantly affect the stem diameter of cocoa plants. The highest stem diameter was obtained in the M3 treatment (25 g/plant), which was 0.68 mm, followed by the M2 (20 g/plant) and M1 (15 g/plant), which were 0.67mm and 0.66 mm.

3.4. Leaf Area

Data from measuring the average leaf area of cocoa plants aged 1-3 WAP are shown in appendices 17, 19, and 21, while the list of variances is in appendices 18, 20, and 22.

Table 4. Test Results Average Effect of Liquid Waste Tofu and Rice Straw Organic Mulch on Leaf Area(cm^2) three months after planting.

Treatment	M1	M2	M3	Average
T0	12.87	13.10	14.93	13.63
T1	14.98	15.87	16.23	15.69
T2	16.27	17.00	17.00	16.76
T3	17.17	17.73	17.83	17.58
Average	15.32	15.93	16.50	

Note: T = Tofu waste. M = Rice straw mulch. Numbers followed by unequal letters in the same treatment column were significantly different at the 5% level based on Duncan's Distance Test. Those that were not notated showed no significant difference.

The investigation revealed that the application of tofu liquid waste, rice straw organic mulch, and their combination had no significant influence on the leaf area of cocoa plants. Table 4 summarizes the results of an average test on the influence of applying tofu liquid waste and organic rice straw mulch on leaf area at the age of 6 WAP.

As shown in Table 4, the treatment of tofu liquid waste, rice straw organic mulch, and their interaction had no significant effect. It was discovered that the provision of tofu liquid waste had the largest leaf area, namely 17.58 cm^2 was obtained in treatment T3 (100 ml/kg), followed by T2 (80 ml/kg), T1 (60 ml/kg), and T0, which were 16.76 cm^2, 15.69 cm^2, and 13.63 cm^2, respectively. Additionally, The application of organic rice straw mulch gave the highest leaf area of 16.50 cm^2 obtained in the M3 (25 g/plant), followed by M2 (20 g/plant) and the M1 (15 g/plant), which were 15.93 cm^2 and 15.32 cm^2, respectively.

3.5. Effect of Tofu Liquid Waste on Cocoa Seed Growth

The results indicated that the liquid tofu waste had a statistically significant impact on plant height, leave, and stem diameter but no effect on leaf area. Furthermore, an increase in the dose of liquid tofu waste generally improved cocoa seedling growth. This is demonstrated by the experimental parameters, which increased directly proportional to the dose of liquid tofu waste.

Stated that tofu liquid waste contains 742 ppm of nitrogen, 20 ppm of phosphorus, and 80 ppm of potassium, promoting plant growth. The nutrients N, P, and K can also promote physiological processes in plants such as cell division, tissue, and organ division, increasing plant height, leaf number, and diameter.

The application of a liquid organic fertilizer leads to the variation of growth rates. According to Hardjowigeno (1987), N plays a role in stimulating vegetative growth, namely increasing plant

height. This is because the availability of nutrients is important in the increase of plant height. The element P is involved in the process of plant organ division and development, K stimulates plant growth points, and Mg is required as a component of chlorophyll (Sarief, 2016).

3.6. Effect of Rice Straw Organic Mulch on Cocoa Seed Growth

The increase in the dose of rice straw organic mulch improved the growth of cocoa seedlings. This is indicated in the experimental parameters which increased along with the higher dose of rice straw organic mulch, although there was no significant effect.

Rice straw organic mulch contains N between 0.5 – 0.8%, P between 0.07 – 0.12%, K between 1.2 – 1.7% (Desiana, 2013), and a C/N ratio of approximately < 15 after the decomposition process to increase plant growth (Neugebauer *et al.*, 2017). According to Asmoro & Susanto (2016), the decomposition process of organic matter takes a long time, in presence of a starter/activator such as microbes. These microbes are an important factor because they will break down organic matter into organic fertilizers. Furthermore, they are biological activators that grow naturally or are intentionally given to accelerate the decomposition process and improve the quality of organic fertilizers. Decomposed organic matter in the soil will release macro and micronutrients to be absorbed by plants (Murbandono, 2000).

The element N absorbed by plants is necessary for vegetative and generative growth, while P is involved in photosynthetic reactions, as well as respiration, and is a component of nucleotides. The element K is also involved in photosynthesis which affects overall plant growth (Yuliarti, 2017).

3.6. Effect of Interaction of Tofu Liquid Waste and Rice Straw Organic Mulch on Cocoa Seed Growth.

The interaction between 100 ml/kg tofu liquid waste and 25 g rice straw organic mulch/plant gave the highest yield on the parameters of plant height as shown in Table 1, many leaves (Table 2), stem diameter (Table 3), and leaf area (Table 4). Although it did not show a significantly different effect. This result is because the combination can provide the elements N, P, and K needed for plants' development growth, thereby increasing the growth and development of cocoa plants (Mei *et al.*, 2020). According to Gunawan (2000), the addition of appropriate N, P, and K nutrients can increase plant growth and production but can inhibit plant growth and development when it exceeds the standards.

4. Conclusions

This study indicated that liquid tofu waste has a significant effect on plant height, leaf number, and stem diameter but there was no effect on leaf area. The T3 treatment (100 ml/kg) is the optimal dose. Organic rice straw mulch significantly increased leaf number, where M3 (25 g/plant) was the most effective treatment. However, no influence was observed for any of the factors when a

mix of tofu liquid waste and organic rice straw mulch was used.

Acknowledgment

The author is grateful to Medan Area University and Alwashliyah University as well as all faculty members and college for supporting this study.

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